A differential diagnostic problem using blood compositions

A clinic is attempting to resolve a difficult problem in differential diagnosis between two types A and B of a blood –related disease and has determined the composition of a group of blood extracts as a possible source of separation. The six-part blood compositions of 50 patients referred to the clinic on the basis of symptoms of anaemia are reproduced below for 25 patients of known type A and 25 patients of known type B. The extract parts are of two distinct forms X and Y.

You are consulted by the clinic and asked three questions.

1. Are the extract compositions of any diagnostic value and how should the compositional information be used in any differential diagnosis of new patients?

2. The Y-form parts are costly and time-consuming to separate and so it would be very helpful to know whether simply measuring the X-forms and the *total* Y-form would provide a reasonable differential diagnostic procedure. How would you answer this question?

3. One clinician even conjectures that total X-form and total Y-form might prove sufficient for diagnostic purposes. What is your view of this conjecture?

Type A patients

	Proportions of parts of blood extracts					
	X1	X2	X3	Y1	Y2	Y3
A1	0.173	0.359	0.232	0.040	0.035	0.159
A2	0.114	0.188	0.314	0.106	0.057	0.218
A3	0.129	0.147	0.112	0.109	0.169	0.331
A4	0.060	0.170	0.539	0.022	0.071	0.135
A5	0.078	0.404	0.303	0.071	0.052	0.089
A6	0.052	0.176	0.250	0.108	0.094	0.317
A7	0.120	0.175	0.317	0.091	0.157	0.138
A8	0.059	0.251	0.176	0.128	0.127	0.256
A9	0.079	0.170	0.315	0.040	0.157	0.235
A10	0.102	0.103	0.328	0.082	0.121	0.261
A11	0.031	0.116	0.572	0.036	0.062	0.181
A12	0.068	0.153	0.403	0.056	0.076	0.241
A13	0.143	0.221	0.207	0.073	0.112	0.241
A14	0.024	0.229	0.219	0.079	0.132	0.314
A15	0.160	0.222	0.320	0.107	0.076	0.111
A16	0.080	0.086	0.291	0.079	0.094	0.367
A17	0.151	0.091	0.375	0.077	0.182	0.121
A18	0.060	0.195	0.302	0.049	0.109	0.283
A19	0.048	0.159	0.174	0.061	0.038	0.519
A20	0.064	0.133	0.416	0.071	0.094	0.221
A21	0.080	0.095	0.389	0.101	0.061	0.272
A22	0.134	0.204	0.240	0.109	0.158	0.152
A23	0.073	0.211	0.460	0.030	0.125	0.098
A24	0.088	0.301	0.317	0.078	0.091	0.122
A25	0.132	0.255	0.250	0.063	0.111	0.185

Type B patients

	Proportions of parts of blood extract					
	X1	X2	X3	Y1	Y2	Y3
B1	0.042	0.144	0.183	0.184	0.085	0.360
B2	0.059	0.086	0.373	0.294	0.056	0.128
B3	0.070	0.100	0.138	0.118	0.110	0.463
B4	0.018	0.127	0.100	0.313	0.080	0.359
B5	0.057	0.147	0.115	0.165	0.167	0.346
B6	0.033	0.080	0.136	0.185	0.117	0.446
B7	0.048	0.139	0.105	0.079	0.148	0.477
B8	0.052	0.153	0.090	0.204	0.088	0.410
B9	0.102	0.154	0.200	0.073	0.078	0.390
B10	0.055	0.116	0.079	0.366	0.075	0.306
B11	0.033	0.080	0.030	0.218	0.098	0.537
B12	0.087	0.118	0.083	0.114	0.144	0.453
B13	0.067	0.061	0.084	0.422	0.118	0.246
B14	0.034	0.063	0.079	0.288	0.098	0.436
B15	0.150	0.074	0.253	0.147	0.059	0.314
B16	0.026	0.100	0.113	0.138	0.137	0.484
B17	0.057	0.100	0.159	0.204	0.029	0.448
B18	0.023	0.078	0.114	0.152	0.026	0.603
B19	0.058	0.266	0.099	0.122	0.080	0.374
B20	0.020	0.082	0.198	0.395	0.041	0.261
B21	0.035	0.161	0.127	0.215	0.137	0.322
B22	0.039	0.061	0.153	0.135	0.202	0.408
B23	0.047	0.071	0.119	0.328	0.038	0.394
B24	0.050	0.170	0.157	0.063	0.254	0.302
B25	0.028	0.069	0.218	0.177	0.048	0.458

4. A second clinic has recently devised a new separation method by which, at a first stage, it can quickly and cheaply separate X1 from X2 + X3 and Y1 from Y2+Y3 before undertaking a subsequent slow and expensive second stage, separating X2 and X3, and Y2 and Y3. The clinic has not yet accumulated enough data to allow it to decide whether the first stage separation would be sufficient to provide a reasonable diagnostic system. The clinic director asks you to use the first clinic's experience to provide a view on this issue.